SPECIFICATION

UCP-2 Promoter and Use Thereof

CROSS-REFERENCES TO RELATED APPLICATIONS

The present invention is a 35 U.S.C. §371 national stage of PCT application PCT/JP99/07198, filed December 22, 1999, which claims priority of Japanese Application Serial Number 366719/1998, filed December 24, 1998.

FIELD OF THE INVENTION

This invention relates to a novel promoter for gene expression and its use. Specifically, this invention relates to a DNA containing the promoter region of human uncoupling protein-2 (UCP-2) gene, a transformant transformed with the said DNA, and a method for screening a compound or its salt that promotes or inhibits UCP-2 promoter activity.

BACKGROUND OF THE INVENTION

Uncoupling protein (UCP) is a proton transporter present in the mitochondrial inner membrane. Since UCP changes intracellular energy stored as fat to heat without using other energy consuming processes, UCP is considered to play an important role in maintenance of body temperature in homeothermal animals. Because of this function, UCP is considered to be an important factor that determines the efficiency of energy metabolism in homeothermal animals.

Three molecular species of uncoupling proteins have been identified to date, and are called uncoupling proteins-1 (UCP-1), -2 (UCP-2 or UCPH), and -3 (UCP-3).

UCP-1, the first isolated among the uncoupling protein family, is specifically expressed in brown fat

cells (Line, C.S. and Klingerberg, M. (1980), FEBS Lett., 113, 299-303; Jacobsson, A. et al. (1985), J. Biol. Chem., 260, 16250-16254; Bouillaud, F. et al. (1986), J. Biol. Chem., 261, 1487-1490). UCP-2 was isolated as a homologue of UCP-1, and confirmed to be widely expressed in various organs (Gimeno, R.E. et al. (1997), Diabetes, Vol. 46, 900-906; Fleury, C., et al. (1997), Nature Genet., Vol. 15, 269-272). UPC-3 was isolated as a UCP specifically expressed in muscles (Vidal-Puig, A. et al. (1997), Biochem. Biophys. Res. Commun., Vol. 235, No. 1, 79-82; Boss, O. et al. (1997), FEBS Lett., 408, 33-38).

Generally, UCP-1 is considered to play an important role in maintenance of body temperature in rodents and hibernants. Basically, the number of brown fat cells that mainly express UCP-1 is lower in large sized animals and animal species inhabiting relatively warm climates (Rothwell, N.J. and Stock, M.J. (1979), Nature, Vol. 281, 31-35). Thus, in these animals including humans, UCP-2 or UCP-3, not UCP-1, may mainly be responsible for the control of the normal body temperature maintenance system and energy consuming process (Hosoda, K. et al. (1998), Obesity Research (Himan Kenkyu), Vol. 4, No. 3, 31-35; Enerback, S. et al. (1997), Nature, Vol. 387, 90-93).

Therefore, it may be possible to adjust the energy consumption/accumulation balance by controlling the gene expression or activity of UCP-2 or UCP-3 in these animals including humans (Hosoda, K. et al. (1998), Obesity Research (Himan Kenkyu), Vol. 4, No. 3, 31-35; Enerback, S. et al. (1997), Nature, Vol. 387, 90-93). In humans, enhancement of energy consumption is considered to promote consumption of not only dietary energy but also energy accumulated as fat. Accordingly, a decrease of body fat in humans may lead to

improvement of obesity, the major cause of lifestyle diseases which become a problem in developed countries in recent years (Fleury, C. et al. (1997), Nature Genetics, Vol. 15, 269-272).

UCP-2 is also considered to be the major cause of fever observed in immunological inflammation such as infection, and inhibition of UCP-2 gene activity may reduce fever in immunological inflammation (Shigenaga, F.R. et al. (1998), Biochiem. Biophys. Res. Commun., Vol. 244, No. 1, 75-78).

In animals, especially in higher animals, organs differentiate and mature upon biogenesis, and develop to exert various functions. During this process, various organ-specific proteins are transiently or constantly expressed and provide the organ-specificity.

The general gene expression control system in animals includes the transcription induction system (promoter, enhancer). Promoter regions are generally located adjacent to the 5′ upstream region of base sequences on chromosomes that are normally transcribed into messenger RNAs. Transcriptional regulatory protein is bound to or dissociated from a base sequence generally called the regulatory sequence in promoter regions, by which the transcription level of genes located downstream of the 3′ region is regulated. Therefore, the transcriptional gene expression level can be estimated from the promoter activity to some extent. It is also known that the base sequences located downstream of the 3′ region of a promoter do not affect the promoter activity in most cases. Therefore, promoter activity can be readily measured by substituting the transcribed messenger RNA for a base sequence encoding a protein with detectable enzyme activity (reporter). Recent technical innovation has made measurement of promoter activity

using reporters very sensitive and simple, and measurement of promoter activity is used in drug screening and analysis of biological function.

For example, transcriptional regulatory factors of fat cell differentiation include peroxisome proliferation-activated receptor γ (PPAR γ) (Tontontz, P. et al. (1995), Curr. Opin. Genet. Dev., Vol. 5, 571-576), retinoid X receptor (RXR), CCAAT/enhancer binding protein (C/EBP) (Cornelius, P., et al. (1994), Annu. Rev. Nutr. Vol. 14, 99-129), etc. The transcriptional regulation by these factors is closely involved in the gene expression related to fat cells. It has been reported that the promoter regions of fat cell-related genes including UCP-2 gene contain the binding sequences for these transcriptional regulatory factors (regulatory sequences). These sequences in promoters are considered to play important roles in the actual regulation of UCP-2 transcription in vivo.

Accordingly, substances that enhance expression of UCP-2 or UCP-3 gene and protein may be used as anti-obesity drugs that reduce body fat content. UCP-2 is also considered to be the major cause of fever in immunological inflammation observed in infection, and substances that inhibit UCP-2 gene activity may reduce fever in immunological inflammation.

If a cell line expressing an appropriate reporter gene connected to the promoter region described above is established, the cell line may be used for screening a drug that promotes or inhibits the UCP-2 expression. In screening substances that may be used as anti-obesity drugs, responses more similar to those in vivo can be obtained by including these regulatory sequences in the promoter-reporter system, which is very advantageous in screening human anti-obesity drugs.

However, human UCP-2 promoter containing the regulatory sequence had not yet been identified, and no simple screening method using the promoter described above had been available for substances that affect the human UCP-2 gene expression.

DISCLOSURE OF THE INVENTION

The inventors performed extensive studies, and successfully obtained the human genomic UCP-2 gene using human UCP-2 cDNA fragments as probes in an attempt to establish a screening method for searching substances that affect the human UCP-2 gene expression. The gene was digested with restriction enzymes, and a 6.5 kb DNA of the upstream region containing a part of the structural gene encoding UCP-2 was obtained. From the DNA obtained, a 3.5 kb DNA containing the base sequence deduced to be the 1st and 2nd exons (2.5 kb DNA as the 5' upstream region) was re-cloned in plasmid DNA.

A plasmid DNA was constructed by splicing a luciferase gene as a reporter gene downstream of the 3.5 kb DNA. By measuring the luciferase activity in transformants of HepG2 cells and MG-63 cells differentiated to fat cell-like cells, UCP-2 promoter was found in the 3.3 kb DNA of the upstream region of the UCP-2 structural gene. As a result of detailed analysis, the regulatory sequence that may control the expression of UCP-2 was found.

The inventors proceeded with the study based on these findings, and obtained the present invention. The present invention relates to the following:

(1) A DNA containing uncoupling protein-2 (UCP-2)promoter region containing the regulatory sequence;

(2) A DNA described in (1) wherein the regulatory sequence is a sequence containing peroxisome

proliferator response element (PPRE);
(3) A DNA described in (1) wherein the regulatory sequence is a sequence containing CCAAT/enhancer binding protein (C/EBP) binding sequence;
(4) A DNA described in (1) wherein the promoter region is a base sequence represented by position 1 to 2270 of SEQ ID NO: 1 or a base sequence containing a part of the said base sequence;
(5) A recombinant vector containing a DNA described in (1);
(6) A recombinant vector described in (5) containing a DNA having a structural gene under control of UCP-2 promoter region containing a regulatory sequence;
(7) A transformant transformed by a recombinant vector described in (5);
(8) A method for screening a compound or its salt that promotes or inhibits UCP-2 promoter activity characterized by use of a transformant described in (7);
(9) A method for screening a compound or its salt that promotes or inhibits heat production characterized by use of a transformant described in (7);
(10) A method for screening an anti-obesity drug, an antidiabetic drug, a depressor, an antihyperlipemic drug, and an antipyretic drug characterized by use of a transformant described in (7);
(11) A kit for screening a compound or its salt that promotes or inhibits UCP-2 promoter activity characterized by use of a transformant described in (7);
(12) A compound or its salt that promotes or inhibits UCP-2 promoter activity obtained using a screening method described in (8) or a screening kit described in (11);
(13) A compound or its salt that promotes or inhibits

heat production obtained using a screening method described in (9); and

(14) A pharmaceutical composition containing a compound or its salt that promotes or inhibits UCP-2 promoter activity obtained using a screening method described in (8) or a screening kit described in (11).

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A-1F show the base sequence of cDNA containing the human UCP-2 promoter region cloned in Example 1.

Figure 2 shows the luciferase activity measured in Example 2.

Figure 3 shows the luciferase activity measured in Example 3.

Figure 4 shows the structure of the UCP-2 promoter deficient-clones constructed in Example 4. The numbers in the Figure represent the base number starting from the transcription initiation site.

Figure 5 shows the promoter activity measured in Example 4.

BEST MODE OF EMBODIMENT OF THE INVENTION

A DNA containing the UCP-2 promoter region containing the regulatory sequence of this invention may be any DNA containing the regulatory sequence described below with UCP-2 promoter activity.

Specifically, a DNA of this invention may be any DNA containing the base sequence represented by position 1 to 2270 of SEQ ID NO: 1 or a part of said sequence.

A DNA of this invention may be genomic DNA, cDNA, and synthetic DNA derived from human and other mammalian cells (e.g. hepatocytes, splenocytes, neurocytes, glial cells, pancreatic β cells, bone

marrow cells, mesangium cells, Langerhans' cells, epidermal cells, epithelial cells, endothelial cells, fibroblasts, fiber cells, muscle cells, fat cells, immune cells (e.g. macrophages, T cells, B cells, natural killer cells, mast cells, neutrophils, basophils, eosinophils, monocytes), megakaryocytes, synovial cells, chondrocytes, osteocytes, osteoblasts, osteoclasts, mammary cells, and interstitial cells, or precursor cells, stem cells, or cancer cells of said cells, and any tissue in which said cells are present, for example, the brain, each region of the brain (e.g. olfactory bulbs, amygdalloidal nucleus, basal ganglia, hippocampus, thalamus, hypothalamus, cerebral cortex, medulla oblongata, cerebellum), spinal cord, pituitary gland, stomach, pancreas, kidneys, liver, gonads, thyroid gland, gallbladder, bone marrow, adrenal glands, skin, muscle, lung, digestive tract (e.g. large intestine, small intestine), blood vessels, heart, thymus, spleen, salivary glands, peripheral blood, prostate, testes, ovaries, placenta, uterus, bones, cartilages, joints, and skeletal muscles.

Specifically, a recombinant DNA containing the human UCP-2 promoter region of this invention can be obtained as follows.

Using the base sequence corresponding to the previously reported amino acid sequences of human UCP cDNA (Fleury, C. et al. (1997), Nature Genet. Vol. 15, 269-272) as the probes, for example, human genomic library inserted in EMBL3 vector is screened by a publicly known method, and λ phage clones to which the probes hybridize are obtained. A DNA is extracted from these phage clones, and the restriction enzyme map of the human gene inserted in the clones is prepared. DNA fragments are prepared by digestion with restriction enzymes, and the fragments hybridizing to the probes

for the most upstream region of the cDNA are re-cloned in vectors for animal cells such as pCD vector, cDM8 vector (Aruffo, A. and Seed, B. (1987), Proc. Natl. Acad. Sci. USA, 84, 8573-8577), and retrovirus vector (Cone, R.D. and Mulligan, R.C. (1984), Proc. Natl. Acd. Sci. USA, 81, 6349-6353), and *Escherichia coli* plasmids such as pUC vector (Vieira, J. and Messing, J. (1987), Methods in Enzymology, 153, 3-11), and pCR-blunt vector (Ausubel, F.M. et al. (1994), Current Protocols in Molecular Biology), but not limited to these vectors. The base sequences of the cloned DNAs are determined, and the position of the translation initiation codon on the gene can be determined by, for example, comparing the base sequence with the cDNA sequence. The position of the transcriptional initiation site on the gene can also be determined by comparing the base sequence with the 5' end of known cDNA. By investigating motifs throughout the entire sequence, the binding site of known transcriptional regulatory factors can be determined.

The isolated DNA can be used without modification or if necessary, after digestion with restriction enzymes or being bound by linkers.

To measure the promoter activity, a detectable structural gene may be spliced downstream of the promoter region. For the structural gene spliced downstream of the promoter region, various reporter genes are used. For the reporter gene, luciferase gene, chloramphenicol acetyltransferase (CAT) gene, alkaline phosphatase gene, and β-galctosidase gene are commonly used, but any other structural genes for which a method of detecting the gene product is available may be used. To insert the above structural gene into the vector, the structural gene is ligated to an appropriate restriction enzyme site located downstream

of the promoter region in the correct transcriptional orientation.

For the host transformed by the recombinant vector described above, for example, *Escherichia genus*, *Bacillus genus*, yeast, insect cells, insects, and animal cells are used.

Specific examples of the host *Escherichia genus* are *Escherichia coli* K12·DH1 [Proceedings of the National Academy of Sciences of the USA (Proc. Natl. Acad. Sci. USA), Vol. 60, 160 (1968)], JM103 [Nucleic Acids Research, Vol. 9, 309 (1981)], JM109, JA221 [Journal of Molecular Biology, Vol. 120, 517 (1978)], HB101 [Journal of Molecular Biology, Vol. 41, 459 (1969)], and C600 [Genetics, Vol. 39, 440 (1954)].

For the host *Bacillus genus*, for example, *Bacillus subtilis* MI114 [Gene, Vol. 24, 255 (1983)] and 207-21 [Journal of Biochemistry, Vol. 95, 87 (1984)] are used.

For the host yeast, for example, *Saccharomyces cerevisiae* AH22, AH22R$^-$, NA87-11A, DKD-5D, 20B-12, *Schizosaccharomyces pombe* NCYC1913, NCYC2036, and *Pichia pastoris* are used.

For the host insect cells, for example, when the virus is AcNPV, *Spodoptera frugiperda* cells (Sf cells), MG1 cells derived from the middle gut of *Trichoplusia ni*, High Five™ cells derived from *Trichoplusia ni* eggs, *Mamestra brassicae*-derived cells, and *Estigmena acrea*-derived cells are used. When the virus is BmNPV, silkworm-derived cell line *Bombyx mori N* (BmN cells) are used. For said Sf cells, for example, Sf9 cells (ATCC CRL1711), Sf21 cells (Vaughn, J.L. et al., In Vivo, 13, 213-217 (1977)) are used.

For the host insect, for example, silkworm larvae are used [Maeda et al., Nature, Vol. 315, 592 (1985)].

For the host animal cells, for example, monkey COS-7 cells, Vero, Chinese hamster CHO cells (CHO),

dhfr gene-deficient Chinese hamster cells CHO (CHO ($dlfr^-$) cells), mouse L cells, mouse AtT-20, mouse myeloma cells, rat GH3, mouse fibloblast 3T3-L1, human liver cancer cell HepG2 (HepG2 cells), human sarcoma cell MG-63 (MG-63 cells), human FL cells, white fat cells, egg cells, ES cells (Evans, M.J. and Kaufman, K.H. (1981), Nature, 292, 154), and differentiation-induced cells under appropriate differentiation conditions are used.

Animal cells, especially white fat cells, may be used. As a process of DNA transfer to individual animals, egg cells and ES cells (Evans, M.J. and Kaufman, K.H. (1981), Nature, 292, 154) are used.

For the method of transforming these cells, the calcium phosphate method (Graham et al. (1973), Virology, 52, 456), electroporation (Ishizaki et al. (1986), Cell Engineering (Saibo Kogaku), 5, 577), and microinjection are used.

More specifically, for transformation of bacteria of *Escherichia genus*, for example, the methods published in Proc. Natl. Acad. USA, Vol. 69, 2110 (1972) and Gene, Vol. 17, 107 (1982) are used.

Bacteria of *Bacillus genus* can be transformed following, for example, the method published in Molecular & General Genetics, Vol. 168, 111 (1979).

Yeast can be transformed following, for example, the methods published in Methods in Enzymology, Vol. 194, 182-187 (1991) and Proc. Natl. Acad. USA, Vol. 75, 1929 (1978).

Insect cells and insects can be transformed following, for example, the method published in Bio/Technology, 6, 47-55 (1988).

Animal cells can be transformed by, for example, the methods described in Cell Engineering (Saibo Kogaku), Separate Vol. 8, New Cell Engineering

Experimental Protocol, 263-267 (1995) (Shujun-sha) and Virology, Vol. 52, 456 (1973).

The transformant described above is cultured in the presence of the specified compound, and by measuring and comparing the gene product in the cultured material, the ability of controlling the promoter activity of the compound can be examined.

The transformant is cultured by publicly known methods. For the medium for culturing the transformant using *Escherichia* and *Bacillus* hosts, liquid medium is appropriate, such as that which contains carbon source, nitrogen source, inorganic compounds, and other substances necessary for the growth of the transformants. The carbon source includes, for example, glucose, dextrin, soluble starch, and sucrose, etc. The nitrogen source includes, for example, inorganic and organic compounds such as ammonium salts, nitrates, cornsteep liquor, peptone, casein, meat extract, soybean cake, and potato extract, etc. The inorganic compounds include, for example, calclium chloride, sodium dihydrogen phosphate, and magnesium chloride, etc. Yeast extract, vitamins, and growth-stimulating factors may be added. The pH about 5 - 8 is desirable for the culture medium.

For the culture medium for bacteria of *Escherichia genus*, for example, M9 medium containing glucose and casamino acid (Miller, Journal of Experiments in Molecular Genetics, 431-433, Cold Spring Harbor Laboratory, New York, 1972) is preferred. When a higher efficiency of the promoter is required, reagents such as 3-β-indolylacrylic acid may be added. When the host is bacteria of *Escherichia genus*, the bacteria are generally cultured at about 15 - 43°C for about 3 - 24 hours, and the culture may be aerated or stirred if necessary.

When the host is bacteria of *Bacillus genus*, the bacteria are generally cultured at about 30 - 40°C for about 6 - 24 hours, and the culture may be aerated or stirred if necessary.

For the medium for culturing the transformant in yeast host, for example, Burkholder minimum medium [Bostian, K.L. et al., Proc. Natl. Acad. Sci. USA, Vol. 77, 4505 (1980)] and SD medium containing 0.5% casamino acid [Bitter, G.A. et al., Proc. Natl. Acd. Sci. USA, Vol. 81, 5330 (1984)] are used. The pH of the medium is preferably adjusted to about 5 - 8. The culture conditions are generally about 20 - 35°C for about 24 - 72 hours, and the culture may be aerated or stirred if necessary.

For the medium for culture of the transformants in insect cells and insect hosts, Grace's insect medium [Grace, T.C.C., Nature, 195, 788 (1962)] containing appropriate supplements, such as inactivated 10% bovine serum, is used. The pH of the medium is preferably adjusted to about 6.2 - 6.4. Usually, the culture conditions are at about 27°C for about 3 - 5 days, and the culture may be aerated or stirred if necessary.

For the culture medium of the transformants in animal cell hosts, for example, MEM containing about 5 - 20% fetal calf serum [Science, Vol. 122, 501 (1952)], DMEM [Virology, Vol. 8, 396 (1959)], RPMI 1640 medium [The Journal of the American Medical Association, Vol. 199, 519 (1967)], and 199 medium [Proceeding of the Society for the Biological Medicine, Vol. 73, 1 (1950)] are used. The pH is preferably adjusted to about 6 - 8. Usually, the culture conditions are about 30 - 40°C for about 15 - 60 hours, and the culture may be aerated or stirred if necessary.

Specifically, the regulatory sequence may be any

sequence of the base sequence represented by position from 1 to 2270 of SEQ ID NO: 1 to which the UCP-2 transcriptional regulatory factor can bind, such as sequences containing peroxisome proliferator response element (PPRE) represented by position 284 to 296 of SEQ ID NO: 1, sequences containing CCAAT/enhancer binding protein (C/EBP) binding sequence represented by position 1316 to 1320, 1364 to 1368, or 1698 to 1692 of SEQ ID NO: 1, sequences containing glucocorticoid response element (GRE) represented by position 753 to 758, 1023 to 1030, or 1450 to 1455 of SEQ ID NO: 1, and sequences containing MyoD represented by position 1428 to 1437 of SEQ ID NO: 1.

Therefore, a DNA of this invention contains the promoter region containing the said regulatory sequence, and a DNA of this invention may contain multiple numbers of the said regulator sequences.

For the base sequences containing a part of the base sequence represented by position 1 to 2270 of SEQ ID NO: 1, any base sequences containing the regulatory sequence described above may be used. Specifically, the base sequence represented by position 255 to 430 of SEQ ID NO: 1, the base sequence represented by position 255 to 717 of SEQ ID NO: 1, the base sequence represented by position 717 to 1133 of SEQ ID NO: 1, the base sequence represented by position 1133 to 1389 of SEQ ID NO: 1, and the base sequence represented by position 255 to 1857 of SEQ ID NO: 1 are used.

Furthermore, the base sequence represented by position 571 to 2270 of SEQ ID NO: 1, the base sequence represented by position 717 to 2270 of SEQ ID NO: 1, the base sequence represented by position 1133 to 2270 of SEQ ID NO: 1, the base sequence represented by position 1389 to 2270 of SEQ ID NO: 1, and the base sequence represented by position 1634 to 2270 of SEQ

ID NO: 1 are used.

Since a DNA of this invention contains the UCP-2 promoter region containing the regulatory sequence, using the transformant described above, a compound or its salt that promotes or inhibits UCP-2 promoter activity (e.g. a compound that promotes or inhibits heat production) can be screened. The said screening method, screening kit, and the said compound or its salt that promotes or inhibits UCP-2 promoter activity obtained using the said screening method and screening kit are specifically explained below.

(1) A method for screening a compound or its salt that promotes or inhibits UCP-2 promoter activity (e.g. a compound that promotes or inhibits heat production)

A transformant transformed by the DNA of this invention described above is useful for searching for and identifying a compound or its salt that promotes or inhibits UCP-2 promoter activity of this invention.

A method for identifying a compound or its salt that promotes or inhibits UCP-2 promoter activity of this invention is characterized by measuring and comparing polypeptide expression between a transformant of this invention contacting a test compound and the transformant lacking the UCP-2 promoter region of this invention contacting the test compound.

The said test compound includes peptides, proteins, non-peptide compounds, synthetic compounds, and fermentation products, etc., and these test compounds may be novel compounds or known compounds.

For the polypeptide to be expressed, polypeptides encoded by the structural genes described above (preferably reporter genes) are used.

For the quantification method of polypeptide expression, for example, quantification of luciferase

activity according to the method described by Brasier, A.R. et al. (1989) in Biotechniques Vol. 7, 1116-1122, is used.

(2) A kit for screening a compound or its salt that promotes or inhibits UCP-2 promoter activity (e.g., a compound that promotes or inhibits heat production)

A kit for identifying a compound or its salt that promotes or inhibits UCP-2 promoter activity (e.g., a compound that promotes or inhibits heat production) is characterized by use of the transformant described above. Examples of the kit for identifying a compound or its salt that promotes or inhibits UCP-2 promoter activity of this invenstion are as follows.

① Screening reagents

1. Cell culture medium

Dulbecco's modified Eagle's medium (Gibco Co.) supplemented with 10% fetal calf serum (Gibco Co.)

2. Cell differentiation medium

Dulbecco's modified Eagle's medium (Gibco Co.) supplemented with 5% rabbit serum (Gibco Co.)

3. Plasmid for measurement of UCP-2 promoter activity

pGL3-basic (Promega Co.) plasmid DNA carrying UCP-2 promoter sequence of this invention and a structural gene (e.g. luciferase gene) inserted downstream of the UCP-2 promoter

4. Host cell line

MG-63 cells (osteosarcoma cell line, obtained from ATCC)

5. Test compounds

Aqueous solutions are stored at 4°C or -20°C, and diluted to 1 μM with cell differentiation medium at the time of use. Test compounds that are slightly soluble in water are dissolved in dimethylforamide, DMSO, and methanol.

② Screening method

Host cells are seeded in 96-well microplates at a density of 1×10^5 cells/well, and cultured in an incubator at 37°C in 5% CO_2 overnight.

The cells are transfected with 1 μg/well of plasmid for UCP-2 promoter activity measurement.

One hour after transfection, 0.1 ml of test compound is added to each well, and the cells are cultured in an incubator at 37°C in 5% CO_2 for 48 hours.

After culture, 0.1 ml of PicaGene LT (Toyo Ink Co.) is added to each well, stirred for five minutes, and then the luminescence is measured using a 96-plate measurement system (Amersham-Pharmacia Co.).

(3) A compound or its salt that promotes or inhibits UCP-2 promoter activity (e.g. a compound that promotes or inhibits heat production) obtained using the screening method described in (1) and the screening kit described in (2)

If a compound that promotes or inhibits UCP-2 promoter activity is found using the screening method described in (1) or the screening kit described in (2), the compound may be used as a prophylactic or therapeutic drug for obesity syndrome because the compound increases or promotes heat production, and thus, the compound may be used as a radical therapeutic drug for lifestyle diseases (diabetes, hypertension, hyperlipidemia). Therefore, the compound may be used as an anti-obesity drug, an antidiabetic drug, a depressor, and an antihyperlipemic drug.

When the compound reduces or inhibits the promoter activity, the compound may be used as an antipyretic drug because the compound decreases or inhibits heat production.

A salt of the compound obtained using the screening method or the screening kit described above includes a pharmaceutically acceptable salt. For

example, salts formed with inorganic bases, organic bases, inorganic acids, organic acids, and basic and acidic amino acids are used.

Preferred salts formed with inorganic bases include alkaline metal salts such as sodium salts and potassium salts, alkaline earth metal salts such as calcium salts and magnesium salts, and aluminum salts and ammonium salts, etc.

Preferred salts formed with organic bases include salts formed with trimethylamine, triethylamine, pyridine, picoline, 2,6-lutidine, ethanolamine, diethanolamine, triethanolamine, cyclohexylamine, dicyclohexylamine, and N,N'-dibenzylethylenediamine, etc.

Preferred salts formed with inorganic acids include salts formed with hydrochloric acid, hydrobromic acid, sulfuric acid, and phosphoric acid, etc.

Preferred salts formed with organic acids include salts formed with formic acid, acetic acid, propionic acid, fumaric acid, oxalic acid, tartaric acid, maleic acid, citric acid, succinic acid, malic acid, methanesufonic acid, benzenesulfonic acid, and benzoic acid, etc.

Preferred salts formed with basic amino acids include salts formed with arginine, lysine, and ornithine, etc., and preferred salts formed with acidic amino acids include salts formed with aspartic acid and glutamic acid, etc.

When the said compound or its salt is used as a prophylactic and/or therapeutic drug for the diseases described above, the preparation can be provided by conventional methods.

For example, the said compound or its salt can be orally administered as sugar coated tablet, capsule,

elixir, and microcapsule, etc., or non-orally as injection such as aseptic solution in water or other pharmaceutically acceptable liquid and suspension. Preparations can be manufactured by, for example, mixing with physiologically acceptable known carrier, flavor, filler, vehicle, antiseptic, stabilizer, and binder in a unit-dosage form required for generally approved drug preparation. The amount of the active ingredient is set for preparation of an appropriate dosage within the specified range.

For the additive miscible with tablets and capsules, for example, binders such as gelatin, cornstarch, tragacanth and acacia, fillers such as crystalline cellulose, swellings such as cornstarch, gelatin, and alginic acid, lubricants such as magnesium stearate, sweeteners such as sucrose, lactose and saccharin, and flavors such as peppermint, akamono oil and cherry are used. When the unit-dosage form is a capsule, a liquid carrier such as fat or oil may be included. Aseptic compositions for injection can be formulated following the usual preparation procedure, such as dissolving or suspending the active substance in vehicle, e.g., water for injection, and natural plant oils, e.g., sesame oil and coconut oil. For an aqueous solution for injection, for example, physiological saline and isotonic solutions (e.g., D-sorbitol, D-mannitol, sodium hydrochloride) containing glucose and other adjuvant(s) are used. Appropriate dissolution-assisting agents, for example, alcohol (e.g., ethanol), polyalcohol (e.g., propylene glycol, polyethylene glycol), and nonionic surfactant (e.g., polysorbate 80(TM), HCO-50) may be combined. For an oil-based solution, for example, sesame oil and soybean oil are used, and dissolution-assisting agents such as benzyl benzoate and benzyl alcohol may be

combined.

The prophylactic/therapeutic drugs described above may be combined with, for example, buffers (e.g., phosphate buffer, sodium acetate buffer), soothing agents (e.g., benzalkonium chloride, procaine hydrochloride), stabilizers (e.g., human serum albumin, polyethylene glycol), preservatives (e.g., benzylalcohol, phenol), and antioxidants. The preparation for injection is usually filled in appropriate ampoules.

The preparations obtained as described above are safe and low toxic, and can be administered to, for example, humans and mammals (e.g., rats, mice, rabbits, sheep, pigs, cattle, cats, dogs, monkeys, etc.).

The dosage of the said compound or its salt differs depending on the target individual, target organ, symptoms, and administration method, etc. When it is administered orally, in general, for adults (60 kg body weight), about 0.1 - 100 mg per day, preferably about 1.0 - 50 mg per day, more preferably about 1.0 - 20 mg per day is administered. When it is administered non-orally, the dosage per dosing differs depending on the target individual, target organ, symptoms, and administration method, etc. For example, in case of injection in general, for adults (60 kg body weight), it is desirable to intravenously inject about 0.01 - 30 mg per day, preferably about 0.1 - 20 mg per day, more preferably about 0.1 - 10 mg per day. Converting the dosage for 60 kg, the said compound or its salt can be administered to other animals.

In this specification and drawings, the codes of bases and amino acids are according to IUPAC-IUB Commission on Biochemical Nomenclature or common codes in the art. The examples are shown below. For amino acids that may have an optical isomer, the L form is

presented unless specified otherwise.

DNA : deoxyribonucleic acid

cDNA : complementary deoxyribonucleic acid

A : adenine

T : thymine

G : guanine

C : cytosine

The SEQ ID NOs shown in the Sequence Listing of this Specification present the sequences below.

[SEQ ID NO: 1] Base sequence of cDNA containing human UCP-2 promoter region cloned in Example 1.

[SEQ ID NO: 2] Synthetic DNA used in screening of cDNA containing human UCP-2 promoter region.

[SEQ ID NO: 3] Synthetic DNA used in screening of cDNA containing human UCP-2 promoter region.

[SEQ ID NO: 4] Synthetic DNA used in screening of cDNA containing human UCP-2 promoter region.

[SEQ ID NO: 5] Synthetic DNA used in screening of cDNA containing human UCP-2 promoter region.

EXAMPLES

The present invention is explained in detail below showing examples, but it is not intended to limit the scope of this invention to the description.

Escherichia coli transformant TOP10/pCR-ucp2p5'#1-10 obtained in the Example 1 described below was deposited with the Ministry of International Trade and Industry, Agency of Industrial Science and Technology, National Institute of Bioscience and Human Technology (NIBH) as deposit number FERM BP-6587 on November 24, 1998 and with Institute for Fermentation, Osaka (IFO) as deposit number IFO 16219 on November 11, 1998.

Example 1 Cloning of human UCP-2 cDNA

Using 0.5 ng of human kidney cDNA (Clontech

Laboratory, California, USA) as the template and the base sequence of base number 55 to 82: 5'-ATGGTTGGGTTCAAGGCCACAGATGTGCCC-3' (SEQ ID NO: 2) of previously reported human UCP-2 cDNA [Gimeno, R. et al. (1997), Diabetes, Vol. 46, 900-906] and the base sequence complementary to base number 1300 to 1329: 5'-ATACAGGCCGATGCGGACAGAGGCAAAGCT-3' (SEQ ID NO: 3) as oligonucleotide primers, human UCP-2 gene was amplified by PCR (after heating at 94°C for 5 min., a cycle consisting of heating at 94°C for 1 min, 55°C for 0.5 min and 72°C for 1.5 min was repeated 30 times, followed by heating at 72°C for 5 min), then inserted into pCR-blunt vector. Using this plasmid DNA carrying the insert as the template, oligonucleotide primers were prepared, and probes were prepared using PCR DIG probe synthesis kit (Boehringer-Mannheim Co.) following the enclosed instructions. Using the prepared probes, a human genomic DNA library (Clontech Laboratory, California, USA) in 3×10^6 phage was screened using nitrocellulose filters. Plaque hybridization was performed using DIG Easy hyb (Boehringer-Mannheim Co.), DIG Wash and Block Buffer Set (Boehringer-Mannheim Co.), and DIG nucleic acid detection kit (Boehringer-Mannheim Co.) following the enclosed instructions. As a result, eight positive clones were obtained from 3×10^6 phage. Of these clones, an inner primer of non-coding exon of previously reported human UCP-2 cDNA sequence [Gimeno, R.E. et al. (1998), Diabetes, 47 (4), 685-687] was synthesized (5'-CAAAGCTGCCAGTGGCTATCATGGCCCG-3') (SEQ ID NO: 4), and a clone containing the non-coding exon was detected by PCR using a primer containing EMBL3 sequence (5'-GACCGGTCGACCCAGATCTGGGTCGACCTG-3') (SEQ ID NO: 5), and a genomic clone containing the 5' upstream region of UCP-2 was obtained. From the

genomic clone, a 3.5 kbp fragment containing UCP-2 promoter region was prepared and inserted into pCR-blunt vector (Invitrogen Co.), and transformant *E. coli* TOP/10 pCR-UCP2P5' #1-10 was prepared. After that, the restriction enzyme map was prepared, and the base sequence was determined. The determined base sequence (SEQ ID NO: 1) is shown in Figures 1A-1F. As shown in Figures 1A-1F, base number 2271 - 2326 and 3416 - 3505 were completely consistent with human UCP-2 cDNA (Gimeno, R.E. et al. (1998), Diabetes, 47 (4), 685-687). Furthermore, the terminal base sequences of the conserved regions were consistent with the Shahnborn rule, which is the characteristic of intron-exon boundary base sequence, suggesting that the conserved base sequences are introns. A sequence likely to be a CpG island (base number about 2070 - 2270), which is a characteristic of promoters not containing a TATA-box sequence, was also confirmed upstream of the first exon. In the promoter sequence described above, PPRE (base number 284 - 296), which is the regulatory sequence of promoters of fat cell-related genes, and three C/EBP binding sites (base number 1316 - 1320, 1364 - 1368, 1698 - 1692) were confirmed.

Example 2 Examination of human UCP-2 gene promoter activity

To confirm the promoter activity of the cloned genomic DNA fragment, a luciferase assay was performed. pGL3-Basic plasmid (Promega Co.) carrying firefly luciferase gene as the reporter gene was used for the vector. As the internal standard, pRL-SV40 plasmid (Promega Co.) expressing sea pansy luciferase under control of SV40 promoter was used.

An EcoRI fragment (3.5 kbp) was isolated from the genomic human UCP-2 DNA and blunted using Blunting

High Kit (TOYOBO Co.), and then ligated to SmaI-digested pGL3-Basic plasmid DNA. Following the above procedure, a human UCP-2 promoter/luciferase vector (pGL3-UCP2) was constructed in which the base number 1 - 3505 shown in Figures 1A-1F was inserted into pGL3-Basic vector. The constructed human UCP-2 promoter/luciferase vector was transiently transfected in HepG2 cells, in which constant expression of UCP-2 was confirmed by RT-PCR, and the activity was examined.

HepG2 cells were seeded in 24-well multiplates (Nunk Co.) at a density of 60,000 cells/well, and cultured at 37°C in 5% CO_2 overnight. Using SuperFect Transfection Reagent (QIAGEN Co.), cells were transiently transfected with 1 μg of human UCP-2 promoter/luciferase vector DNA or pGL3-Basic DNA and 0.1 μg of pRL-SV40 DNA. The procedure was performed according to the enclosed instructions. Then, the cells were cultured at 37°C in 5% CO_2 for 24 hours, and the luciferase activity was detected using PicaGene Dual Sea Pansy (Nippon Gene Co.) according to the enclosed instructions. The measurement data were presented as relative activity to the internal standard value of pRL-SV40-derived sea pansy luciferase activity. The results are shown in Figure 2. The human UCP-2 promoter/luciferase vector-derived luciferase activity was markedly higher than that of pGL3-Basic lacking the promoter. Therefore, the genomic DNA of human UCP-2 gene of this invention has a promoter activity reflecting the in vivo UCP-2 gene expression system.

Example 3 Examination of human UCP-2 gene promoter activity in human differentiated fat cell-like cells

Using the human UCP-2 promoter/luciferase vector DNA obtained in Example 2, the promoter activity in

human fat cell-like cells differentiated from MG-63 cells was confirmed.

MG-63 cells were seeded in 24-well multiplates (Nunk Co.) at a density of 100,000 cells/well, and cultured at 37°C in 5% CO_2 overnight. Using SuperFect Transfection Reagent (QIAGEN Co.), cells were transiently transfected with 1 μg of human UCP-2 promoter/luciferase vector DNA or pGL3-Basic DNA and 0.1 μg of pRL-SV40 DNA. The procedure was performed according to the enclosed instructions. The culture medium was replaced with Dulbecco's modified Eagle's medium (DMEM) (Gibco Co.) containing 5% rabbit serum (Gibco Co.), and differentiation to fat cell-like cells was induced. Then, the cells were cultured at 37°C in 5% CO_2 for 24, 36, and 72 hours. After culturing, the luciferase activity was detected in each culture as described in Example 2. The measurement data were presented as relative activity to the internal standard value of pRL-SV4-derived sea pansy luciferase activity. The results are shown in Figure 3. The human UCP-2 promoter/luciferase vector-derived luciferase activity was markedly higher than that of pGL3-Basic lacking the promoter in fat cell-like cells differentiated from human MG-63 cells. Therefore, the genomic DNA of human UCP-2 gene of this invention has the promoter activity reflecting the in vivo UCP-2 gene expression system in fat cell-like cells differentiated from human MG-63 cells.

Example 4 Preparation of human UCP-2 promoter-deficient vector

The human UCP-2 promoter/luciferase vector prepared in Example 2 was digested with KpnI and MluI, and the human UCP-2 promoter-deficient vector shown in Figure 4 was prepared using the Deletion Kit for Kilo-

Sequence (Takara Shuzo Co.) by following the protocol. The plasmid digested with KpnI and MluI was purified by phenol extraction and ethanol precipitation. Then, the precipitated DNA was treated with exonuclease III and sampled every one minute, and the reaction was terminated. The samples were treated with Mung bean nuclease and the ends were blunted. The ends were restored by Klenow fragment, and the DNA was circularized by DNA ligase. The circularized DNAs were re-treated with MluI to linearize plasmids in which deletion did not occur. *E. coli* JM 109 competent cells (Takara Shuzo Co.) were transformed with this reaction solution. The deficient clone plasmids thus obtained were purified by publicly known methods. The molecular weights of the deficient plasmids were confirmed by agarose gel electrophoresis, and clones were selected. The base sequences of these clones were confirmed by publicly known method.

Using these plasmids, the promoter activity was measured by the procedure described in Example 2 (Figure 5).

When the base sequence containing PPRE (base number 284 - 296) shown in Example 1 was deleted, about 70% increase in the UCP-2 promoter activity was oberved, suggesting that this sequence region has a UCP-2 promoter suppressor activity. When the base sequence containing the two C/EBP binding sites (base number 1316 - 1320 and 1364 - 1368) was deleted, about 30% of the UCP-2 promoter activity decreased, suggesting that the base sequence containing these two C/EBP binding sites has a UCP-2 promoter enhancer activity. When 290 bases were deleted from the transcriptional initiation site toward downstream, no UCP-2 promoter activity was detected. Therefore, the genomic DNA of human UCP-2 gene of this invention has

a promoter activity reflecting the in vivo UCP-2 gene expression control system.

INDUSTRIAL APPLICABILITY

Since UCP-2 promoter of this invention contains the regulatory sequence, it has higher activity reflecting the in vivo UCP-2 DNA expression system in humans than the promoter lacking the regulatory sequence. Therefore, the UCP-2 promoter of this invention can be used as a promoter inserted in vectors for treatment of human diseases and providing drug-screening systems under conditions closer to the in vivo environment in humans.